UNPUBLISHED PRELIMINARY DATA

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Gentlemen:

Enclosed please find semi-annual reports for NASA Grant No. NSG-78-60 entitled "The use of higher plants in a large microcosm". This is divided into two parts, "The use of pathogen-free plants in a microcosm" (Ralph Baker, Principal Investigator), and "The effects of high intensity light on plant growth" (Frank Salisbury, Principal Investigator).

Sincerely,

Ralph Baker
Professor

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The Use of Pathogen-free Plants in a Microcosm

1. Experiments have continued on the characteristics of growth of germ-free plants. Various lines of evidence have indicated that plants grow more slowly in germ-free environments:

   A. Beans have been grown successfully for two generations in a germ-free condition. Growth in the second generation was slower than in the first.

   B. Growth of tomato plants is significantly less than in a germ-free environment during a 42 day growth period.

   C. Tomato plants grown germ-free for two weeks, then reinfested had a higher growth rate than germ-free plants. This is not statistically significant but holds true for successive experiments.

   D. Some of these results can be attributed to variations in nutrient balance and pH but repeated experiments indicate that certain micro-organisms are essential for "normal" growth of plants.

2. Competition in a three membered system has been demonstrated. The system consisted of a host (bean), a pathogen (Fusarium solani f. phaseoli) and an active competitive saprophyte (F. roseum). The presence of the competitive saprophyte decreased the pathogenicity of the pathogen on the host. Pathogenicity was reduced further by manipulation of the soil environment so that nitrogen became limiting. This is an example of the possibilities of biological buffering of a soil to decrease the effects of harmful organisms and is, to our knowledge, the first demonstration of the phenomenon in a rigorous gnotobiotic system.

3. Plans have been drawn up for a gnotobiotic chamber specifically designed for plants. This has been submitted to the National Science Foundation in a proposal for construction of an experimental prototype.

The Effects of High Intensity Light on Plant Growth

The influence of light intensity, air temperature, wind velocity, radiation environment, and light quality on plant temperature, and the energy transfer mechanisms which control the exchange of energy between the plant and its surroundings were evaluated. Results are herein summarized:

1. Leaves of different plant species heat at a rate inversely proportional to their mass. The heating rate of the leaf and the mass of the leaf are related by a constant which is a function of the environment.

2. The leaf temperature and transpiration rate increase linearly with the energy absorbed by the leaf over a range of energies from 0.14 cal/cm^2/min to 2.79 cal/cm^2/min. The transpiration rate is nearly proportional to the difference between the leaf and ambient temperature. Heat injury in the leaf produced by high levels of radiant energy is accompanied by a decrease in leaf temperature.

3. Calculations with the data of one experiment indicate that at high radiation levels (including both visible and long wave thermal radiation) the dominant means of energy dissipation by leaves is through radiation (63 per cent). Transpiration accounted for 32 per cent of the total energy dissipated by the leaf, and the remaining 5 per cent was assigned to convection.

4. The radiant temperature of the surrounding surfaces to which the leaf radiates or receives thermal energy can significantly influence the leaf temperature. At a constant surface temperature, as the air temperature decreased there was a smaller temperature differential between the leaf and the air.

5. A given amount of radiant energy will produce a greater heating effect in the leaf when the ambient temperature is low. With increasing air temperature, the difference between the leaf temperature and air temperature is decreased until at 35 C the temperature of the leaf is essentially the same as the air. At high air temperatures, increasing wind velocity has little or no influence on the temperature of the leaf. The results indicate that convection, especially at high air temperatures, is not a significant factor in energy transfer from leaves and that radiation and transpiration must account for the largest amount of energy dissipated from leaves.

6. At relatively low ambient temperatures, the transpiration rate and temperature of illuminated leaves decrease linearly with the log of the wind velocity over a range of wind velocities from 0.5-15 ft/sec. Each incremental increase in the velocity of the air passing over the leaf tends to bring the leaf closer to the air temperature.

The decreasing transpiration rate with increasing wind velocity can be explained on the basis that the wind in cooling the leaf (because of increased convective losses) decreases the vapor pressure gradient between the leaf and the air, thus decreasing transpiration in about the same proportion as the leaf temperature was decreased.

7. Leaves which are subjected to radiant energy containing a high proportion of infrared radiation are at a lower temperature and transpire at a lower rate than plants which receive only visible radiation of the same absolute energy. This is due to the fact that less short wave infrared than visible is absorbed by leaves.

8. The foot candle as a photometric unit of light intensity does not give a reliable indication of the energy received by a leaf from different radiant energy sources.